## OUR ASTRONOMICAL COLUMN.

VARIATIONS OF CERTAIN STELLAR SPECTRA.—The November number of the *Monthly Notices of the Royal Astronomical Society* contains a note by the Rev. T. E. Espin, "On the Variation of the Spectra of R Coronæ and R Scuti, and on the Spectra of R Aurigæ and R Andromedæ." The following are the observations recorded :—

*R Coronæ.*

1890 March 26.—Star about 5·8 mag. Colour yellowish-white. Nothing certain seen ; sometimes irregularities, either dark or bright lines suspected.

1890 April 10.—Continuous spectrum, but again suspected lines ; one bright one strongly suspected near the place of F, but believed more refrangible.

1890 September 8.—A most wonderful change has taken place in this star's spectrum. Two large absorption bands have appeared, one in the bluish-green, and one in the bluish-violet. These bands are sharply defined on the least refrangible side. Bringing the spectrum to a line, bright patches were seen far away in the violet—these may be bright lines or bright spaces. The star is now pale yellow. The magnitude still about 6.

1890 September 14.—The spectrum is apparently of the IV. type [Group VI.] since the bands fade away on the more refrangible side, but are sharply defined on the less refrangible. The band in the bluish green was thought to be occasionally resolved into fine lines ; between the two bands a bright line was suspected. The star is of the same magnitude, and now pale orange.

1890 October 8.—The star is only dim, but the bands seem to have faded.

1890 October 10.—The star has now nearly returned to the continuous first type spectrum observed in the spring. The big band in the bluish-green has disappeared, but the band in the violet is probably there still, but faint. The bright line previously mentioned again suspected. The star is now yellowish-white, and the magnitude about the same.

*R Scuti.*

1890 August 21.—III. Type (= Group II.). Bands 1, 2, 3 of Dunér's nomenclature seen, and also 7 and 8, which are the strongest.

1890 August 23.—Estimated 7·2 mag. ; pale orange-red ; carefully examined. Type III., but peculiar. The usual bands 1, 2, 3, seen ; the bands 4 and 5 faint ; 7 and 8 are strong. Bringing the spectrum to a line, bright knots seen in the violet and ultra-violet, either lines or spaces.

1890 September 8.—Bands 4 and 5 much better seen, but the other bands remain the same. The star is now brighter.

1890 October 10.—The star is now about 6 mag. The III. type spectrum is no longer certainly seen. A remnant of band 7 still remains ; the others have almost, if not quite, disappeared. Perhaps 8 is there.

1890 October 12.—The star about 6 mag. Type doubtful ; possibly III., but very indistinct.

1890 October 15.—The star is about 6·5. The spectrum is again clearly III. type. Bands 7 and 8 best seen ; also 1 to 4 visible. The bands are, however, faint and dim, but are larger now, and the spectrum is similar to that observed on August 21.

1890 November 1.—Normal III. type, and about 6·8 mag. The bands are well seen in all parts of the spectrum. Bands 7 and 8 are especially broad.

*R Aurigæ.*

1890 August 18.—Mag. 7·2 ; colour fine rose-red. Very fine III. type, and the spectrum appears to resemble that of Mira rather than that of R Andromedæ.

*R Andromedæ.*

1890 August 23.—Mag. 7·3 ±. Bands not deep except in the blue and violet. Bringing the spectrum to a line, several bright lines in the violet and ultra-violet suspected. F possibly bright.

1890 September 8.—The star has increased in light, and $\gamma$ hydrogen and F certainly seen, but still faint.

1890 September 14.—Bands in the red well seen, the yellow bands faint. F very plain now.

1890 September 15.—The F line now a wonderful spectacle. The star is not so red, the bands are generally faint, except in the red. A bright space in the yellow looks like a mass of fine bright lines. A deep band in the violet—H$\gamma$ and $D_3$—possibly bright.

BRITISH ASTRONOMICAL ASSOCIATION.—The first number of the Journal of this Association has been recently issued. Miss A. M. Clerke has contributed a paper on the rotation periods of Mercury and Venus, in which she brings forward the evidence which led Schiaparelli to the conclusion that their rotation period is the same as their sidereal period of revolution around the sun. Another paper, by the editor, Mr. E. Walter Maunder, entitled "The Chief Nebular Line," deals with the character and position of the chief line seen in the spectrum of the nebulæ, and its probable origin. Beginning with Dr. Huggins's discovery, in 1864, of the character of nebular spectra, it is shown how he suggested that the brightest line was due to an unknown form of nitrogen. This view was widely taught until 1887, when Prof. Lockyer enunciated the principles of his meteoritic hypothesis, and testified to the coincidence of the line with the remnant of the brightest magnesium fluting at λ 5006·5—a statement combated by the later observations of Dr. and Mrs. Huggins. Mr. Keeler's observations of nebular spectra, made at the Lick Observatory with a Rowland grating having 14,438 lines to the inch, demonstrate that the nebular line may appear both *more* and *less* refrangible than the brightest edge of the magnesium fluting. This being so, Mr. Maunder concludes "that we do not know the position of the nebular line with sufficient accuracy to say positively that it does or does not accord with the magnesium fluting." The Journal is supplied free to members of the Association.

ELEMENTS AND EPHEMERIS OF ZONA'S COMET (*e* 1890).—A Royal Astronomical Society circular contains the following elements and ephemeris computed by Dr. Hind. The orbit depends upon an observation at Rome on November 16, one by Baron von Engelhardt on the 18th, and the Paris observations of the 21st.

Perihelion passage, 1890 August 8·43592 G.M.T.

| | ° | ′ | ″ | |
|---|---|---|---|---|
| Longitude of perihelion ($\pi$) ... | 113 | 16 | 52·1 | Appt. Eq. Nov. 20. |
| ,, ,, ascending node (☊) | 85 | 25 | 2·7 | |
| Inclination ($i$) ... ... ... ... | 25 | 38 | 57·4 | |

Perihelion distance, 2·0597 (Earth's mean distance = 1).
The motion of the comet is retrograde.

*Ephemeris for Greenwich Midnight.*

| 1890. | R.A. h. | m. | s. | Decl. ° | ′ | Distance in Terms of the Earth's Mean Distance from the Sun. |
|---|---|---|---|---|---|---|
| Dec. 18 ... | 2 | 42 | 0 ... | +32 | 19·9 ... | 1·757 |
| ,, 20 ... | 2 | 35 | 4 ... | 31 | 53·6 | |
| ,, 22 ... | 2 | 28 | 38 ... | 31 | 27·4 ... | 1·844 |
| ,, 24 ... | 2 | 22 | 42 ... | 31 | 1·5 | |
| ,, 26 ... | 2 | 17 | 14 ... | 30 | 36·0 ... | 1·937 |

The comet is, therefore, still in Perseus, and moving towards Triangulum. The sidereal time at Greenwich at 10 p.m., on December 18 = 3h. 49m. 50s. The intensity of light on December 26 = 0·47, that on November 16, the date of discovery, being taken as unity.

## CHEMICAL ACTION AND THE CONSERVATION OF ENERGY.

THE conservation of energy is accepted as a general principle without question, but its operation is often so disguised, especially in chemical changes, that it is not apparent to a superficial observer, and, as a consequence, it is too often treated as a dead letter.

This is largely due to the enunciations given by thermochemists, who attempt to draw an impossible distinction between chemical and physical changes, and imply that the latter are not subservient to the law of the conservation of energy. The accepted principles of dissociation, together with the recognition of the complex nature of liquid molecules, and of the existence of compounds in solution, gives us, however, the means of explaining *all* the thermal results of any action in accordance with the recognized principles of science (see Chem. Soc. Trans., 1889, 14).

Chemical affinity, or the potential energy possessed by atoms, becomes satisfied to a greater or less extent when these atoms combine together, and a corresponding amount of kinetic energy must be developed. In all ordinary calorimetric operations this kinetic energy takes the form of heat. An "endothermic" compound is, therefore, an impossibility, if the term be used in the sense of a "body formed from its constituent *atoms* with absorption of heat."

The same principle which governs atomic combinations must also govern those complex reactions with which we generally deal. They occur in order to satisfy affinity—in order to convert potential into kinetic energy—and heat *must*, therefore, be liberated during them. If any absorption of heat does occur, it can only be due to some secondary decomposition, which has followed the primary heat-evolving action, owing to the alteration in conditions occasioned by this action. Dissociation affords a simple explanation of the occurrence of such secondary decompositions.

Just as a certain temperature must be attained before any particular combination can occur, so there is a certain temperature above which any particular compound cannot exist; but, owing to the molecules in a mass of fluid being at different temperatures, dissociation begins when the average temperature of the mass is below this point, and is not complete till the average temperature is considerably above it. The stable condition of a fluid at any temperature between these limits is such that there are $\frac{1}{x}$th of the total molecules dissociated: if this condition be disturbed by the removal of any of the dissociation products, other molecules will have to dissociate in order to reproduce it.

The effect of dissociation on the thermal value of any change may be illustrated by the case of carbon dioxide and carbon, which react at 600° to produce carbon protoxide with an absorption of 39,000 cal. At 600° carbon dioxide is partially dissociated, and consists of $x\text{CO}_2 + (1 - x)\text{CO} + (1 + x)\frac{1}{2}\text{O}_2$. With the free oxygen in this mixture the carbon can combine, *evolving* 29,000 cal.; and more of the carbon dioxide must then dissociate to reproduce the stable condition; this dissociation absorbs 68,000, leaving 39,000 cal. as the algebraic sum of the combination and consequent decomposition.

Nearly every series of reactions in which heat is absorbed can, I believe, be fully explained by one of the reagents being to start with in a state of partial dissociation,[1] and in the remaining few a similar explanation is obtained in the dissociation of the product of the reaction.

An exothermic reaction cannot possibly be impeded by the fact that its occurrence will *subsequently* involve a greater absorption of heat. The carbon cannot be supposed to refrain from combining with the free oxygen by the fact that its doing so will disturb the equilibrium of the mass and necessitate the decomposition of other $\text{CO}_2$ molecules. To imagine that it would do so, would be to endow the atoms with intelligence.

The converse fallacy is often held—that an endothermic reaction may occur if it forms part of a cycle of which the final result is an evolution of heat. This is obviously impossible. Unless we endow the molecules with prescience, we can no more imagine that they will react at first so as to increase their stock of potential energy (absorb heat) in order that this stock may subsequently be diminished by the interaction of the bodies first formed, than we can imagine that a stone will roll of its own accord a short way up a hill in order to have a long roll down on the opposite side.

A considerable amount of misconception also exists as to the influence of heat in effecting endothermic reactions. No amount of heating can make an endothermic reaction possible so long as it remains endothermic; but it is, of course, quite possible that a reaction, which would be endothermic at one temperature, may, owing to the relative magnitude of the heat capacities of the reagents, become exothermic at another; or that heating the reagents may induce dissociation, and that the new reagents thus introduced may render an action possible which was impossible with the original reagents.

Another not uncommon error is to imagine that an endothermic reaction may be brought about by the simultaneous occurrence of some independent reaction evolving heat. If the second reaction is really independent of the first, it cannot possibly have any influence on it; the heat liberated during it will be no more capable of rendering the endothermic reaction possible than heat supplied from any other source. Cases in which the contrary appears to take place may be explained either by the formation of new reagents during the exothermic action, or by the previous combination of the body; which reacts exothermically with that which could by itself react endothermically only.

Endothermic changes in which one or more of the reagents is a gas either do not occur directly, or, in the one or two cases where they do so, the thermal value of the reaction at the temperature of its occurrence is not known, or else the results may be easily explained in the same way as in the case of the reaction between carbon and carbon dioxide. The reactions which present serious difficulties are those where one or more of the reagents is liquid, such as (1) the dissolution of a solid in a liquid; (2) the dilution of a strong solution; (3) double decomposition between two substances in solution.

The heat absorbed when a solid salt is dissolved in a solvent—water, for example—must be attributed, not merely to the fusion, but also to the volatilization of the salt, and would amount to 5000 to 15,000 cal. per gram-molecule. To bring this about, some affinity must be brought into play capable of developing more than this amount of heat. Now, the satisfaction of the affinity of a large proportion of water for the salt molecule present develops less—the heat of dissolution is a negative quantity; but the water consists of aggregates of the fundamental molecules in a state of partial dissociation; and, from the fact that water will give off its fundamental molecules (*i.e.* has a vapour tension) at ordinary temperatures, we must conclude, I think, that this dissociation extends so far that some of the fundamental molecules themselves are present. To convert a mass of water at ordinary temperatures into its fundamental molecules (into gas), requires an absorption of 10,000 cal. per $\text{H}_2\text{O}$, so that those fundamental molecules must possess an amount of potential energy equivalent to 10,000 cal. more than that possessed by the average aggregate: they would, consequently, be capable of combining with a salt molecule and evolving 10,000 cal. more per $\text{H}_2\text{O}$ than the average aggregate would, and they would be capable of effecting a combination which the average aggregate could not. The combination of one, or at most two, such fundamental molecules with a salt molecule would evolve more heat than that absorbed in the separation of the salt molecule from its fellows: we have, therefore, the conditions necessary for a possible reaction—a primary action *evolving* heat. The removal of the fundamental water molecules would necessitate the dissociation of other aggregates to supply their place, and these, in their turn, would combine with the salt hydrate present till the highest hydrate capable of existing under the circumstances was formed. The heat absorbed in the decomposition of the water aggregates is, however, nearly entirely counterbalanced by the recombination of the water molecules with each other after they have combined with the salt, for there is independent evidence to show that the water molecules present in a very complex hydrate are as much combined with each other as they are in the aggregates of pure water: thus, the net result obtained, when dissolution is complete, is simply the algebraic sum of two quantities: (1) the heat evolved in the combination of the salt with the water aggregates, (2) the heat absorbed in volatilizing the salt; and, according as the former or latter of these is the greater, so will the heat of dissolution be positive or negative; but the motive power, if I may use such a term, which produces these results is the potential energy possessed by the free water molecules, an energy which enables them to overcome the affinity of the salt molecules for each other, and produce a primary heat-evolving reaction.

The second case in which heat is absorbed by the dilution of a strong solution occurs as a part of the process of the dissolution of a solid salt, and is comprised in the above explanation.

Cases of double decomposition in which heat is absorbed would require too long an explanation for insertion here, and reference must be made to my former communication on this subject: it will suffice to say that they can in all cases be explained in accordance with the principle of there being a primary exothermic reaction, by recognizing the presence of several hydrates of various degrees of complexity, the less complex of these bringing about this primary reaction, and its removal necessitating as a consequence the endothermic decomposition of the higher hydrates to supply its place.

If the three conditions necessary to render a reaction possible exist—(1) a certain proximity of the reagents, (2) a certain affinity, *i.e.* power of developing heat by their reaction,

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[1] The amount of dissociation necessary is almost infinitesimal, and may often be too small to be recognized by other means.

(3) a temperature within certain fixed limits—it follows that the reaction in question must occur; for, if it did not, the atoms would be in a state of strain inconsistent with stability; it would be as if a stone did not fall to the earth when there was nothing to prevent its falling. As a consequence of this, it follows that, in any complex system of atoms, where two or more different arrangements are independently possible, and where the various products remain within the sphere of action, and are capable of further interaction, then, those products, the formation of which is attended with the greater evolution of heat, will be formed to the exclusion of the others; or, if the two actions develop the same amount of heat, they will both occur to an equal extent.

I showed that the division of a base between two acids takes place entirely in accordance with this principle; wherever the salt formed remains undissociated in the liquid, the base is divided equally between the two acids, because the heat of neutralization of all such acids is the same, whereas, in other cases, where one of the salts formed is stable, and the other is in a state of partial dissociation, the undissociated salt is formed to the exclusion of the dissociated one; such small divergencies from this rule as are observed being due to the solutions examined being considerably stronger than they should have been, the heat of neutralization in such cases not exhibiting absolute constancy, and the dissociation of the dissociated salts being incomplete. This simple principle does away with the cumbrous hypothesis that each acid and base possesses a certain "avidity" or "affinity" peculiar to itself—an hypothesis which is, as I then pointed out, at variance with many facts of the case. A very striking confirmation of my views has been afforded by finding that the heat of neutralization of sulphuric acid in very weak solution is normal, thus verifying a prediction which I made on the strength of the above considerations.

I formerly held that the dissociation which explains endothermic reactions cannot be that of the product, but only that of the reagents; this I still think is true in cases where the product would dissociate into the same substances as the reagent would (if this latter could dissociate)—*e.g.* the hydrate of a salt dissociating into water and the elements composing the salt—but it is not true in other cases; for instance, a hydrate formed by dissolving a salt may dissociate into acid and base, and cause thereby an absorption of heat.

As with two possible reactions, where the products remain within the sphere of action, that which develops the most heat will occur to the exclusion of the other, so in two possible decompositions where the products remain within the sphere of action, that which absorbs least heat will occur to the exclusion of the other; and the question consequently arises, Why does a hydrated salt dissociate into acid and base, instead of into the anhydrous salt and water? The probable explanation is that in many cases the latter dissociation would be the more endothermic of the two; for the salt molecules in various contiguous hydrates are so far removed from the sphere of each other's attraction, that their attraction for each other would be practically *nil*, and the hydrate could only dissociate to form water and *free* salt molecules, absorbing in so doing a quantity of heat exceeding the observed heat of dissolution by an amount corresponding to the heat of fusion and volatilization of the salt, and exceeding in many cases the heat of neutralization itself. The presence of excess of water would moreover practically prevent the dissociation of the hydrate into water and the anhydrous salt.

A class of endothermic changes which present considerable difficulties are those which occur without the absorption of external energy in living organisms. We are at present so utterly ignorant of the nature of the reagents and products that it is hopeless to attempt any explanation of the *modus operandi* in these cases, but a suggestion made by Mr. Warrington at the recent meeting of the British Association with regard to the nitrifying organisms indicates the direction in which such an explanation may be obtained on the same principles as those given in the cases here discussed. SPENCER U. PICKERING.

## THE WORKING OF THE TECHNICAL INSTRUCTION ACT AND THE LOCAL TAXATION ACT.[1]

THE Secretaries of the National Association for the Promotion of Technical and Secondary Education, in reporting on the working of the Technical Instruction Act, have to congratulate the Association on the rapid progress which has been made during the last year in taking advantage of the benefits of the Act. This is partly to be ascribed to the grant of a small sum by the Science and Art Department to meet local effort, but chiefly to the allocation to County Councils of England and Wales, under the Local Taxation Act of this year, of a sum amounting in all to £743,000, with permission to use it for the benefit of education over and above any sum that may be raised by rate under the Technical Instruction Act.

*Technical Instruction Act*, 1889.—The number of local authorities in England and Wales which have taken advantage of the Technical Instruction Act has risen from *four* to *forty* since the date of the Manchester Conference a year ago. These districts are as follows:—Atherton, Aberystwith, Barnsley, Birmingham, Birkenhead, Blackburn, Burnley, Burslem, Bridgwater, Bingley, Bolton, Blaenau Festiniog, Cardiff, Coventry, Darwen, Guiseley, Keighley, Kidderminster, Manchester, Maidstone, New Mills, Macclesfield, Northampton, Nottingham, Oxford, Rochdale, Rotherham, Sheffield, Stockport, Salford, Shipley, Sherborne, Southport, Stalybridge, Worcester, Wakefield, Wrexham, Westmoreland, Widnes, and York. This list is probably not complete. In addition to the above, several of the Welsh County Councils have appointed their Intermediate Education Joint Committees to be Committees under the Technical Instruction Act.

*Local Taxation Act*, 1890.—In addition to these districts, a number of counties have taken action in the direction of utilizing the local taxation grant under the machinery of the Technical Instruction Act.

The following English counties have already resolved to set aside the whole or part of the money for education:—

Shropshire has set aside the whole of its share, amounting to £6543, for education, and the Technical Instruction Committee has presented a valuable report on the use of the money.

Somersetshire has set aside the whole of its share, about £11,000, for education, and is now engaged in considering applications.

The Technical Instruction Committee of Hertfordshire has recommended that the whole of the sum (£6429) be devoted to education.

Staffordshire has voted £7000 for education, and a scheme for its distribution is being framed.

Oxfordshire has set aside half of the grant, about £2000, for education, and Gloucestershire has also voted half the grant for the same purpose.

The North Riding of Yorkshire has voted £2000 for education.

Cheshire and Devonshire have determined to devote some part of the fund to education.

Leicestershire gives £300 to the Leicestershire Dairy Association, and Westmoreland gives £250 to existing schools, to be spent on apparatus.

The county borough of Croydon has voted the new fund to meet capital expenditure on technical instruction.

Besides these twelve districts (eleven counties and one county borough) which have definitely voted the whole or part of the new fund for education, the subject is now receiving careful consideration in a large number of districts, in many of which the new fund is practically certain to be applied, at least in part, to educational purposes.

Conspicuous among these districts is the county of Lancashire, which was the first to move in the matter, having appointed a Technical Instruction Committee in August last, which is just now reporting results of exhaustive inquiries as to the best means of assisting education from the new fund. Essex also has advertised for applications for a share of the money, and is now considering such applications with a view to assisting technical education. Committees have been appointed to consider the question in the following twenty counties:—Kent, Wiltshire, Cornwall, Berkshire, Northumberland, Peterborough, Southampton, Cumberland, Durham, East and West Sussex, Cambridgeshire, Worcestershire, Warwickshire, Dorset, West Riding, East Riding, Bedfordshire, and Herefordshire, and London. In London, however, the bulk of the grant for the present year has been used for the reduction of rates.

A large number of county boroughs are considering the desirability of using the new money for education. It is stated to be most probable that it will be so used in Nottingham, Salford, Blackburn, and Bradford. Worcester proposes to increase its grant under the Technical Instruction Act by £450, to be taken out of the new fund.

In addition to the above, the following county boroughs

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[1] Secretaries' Report, read at the Conference on December 5.